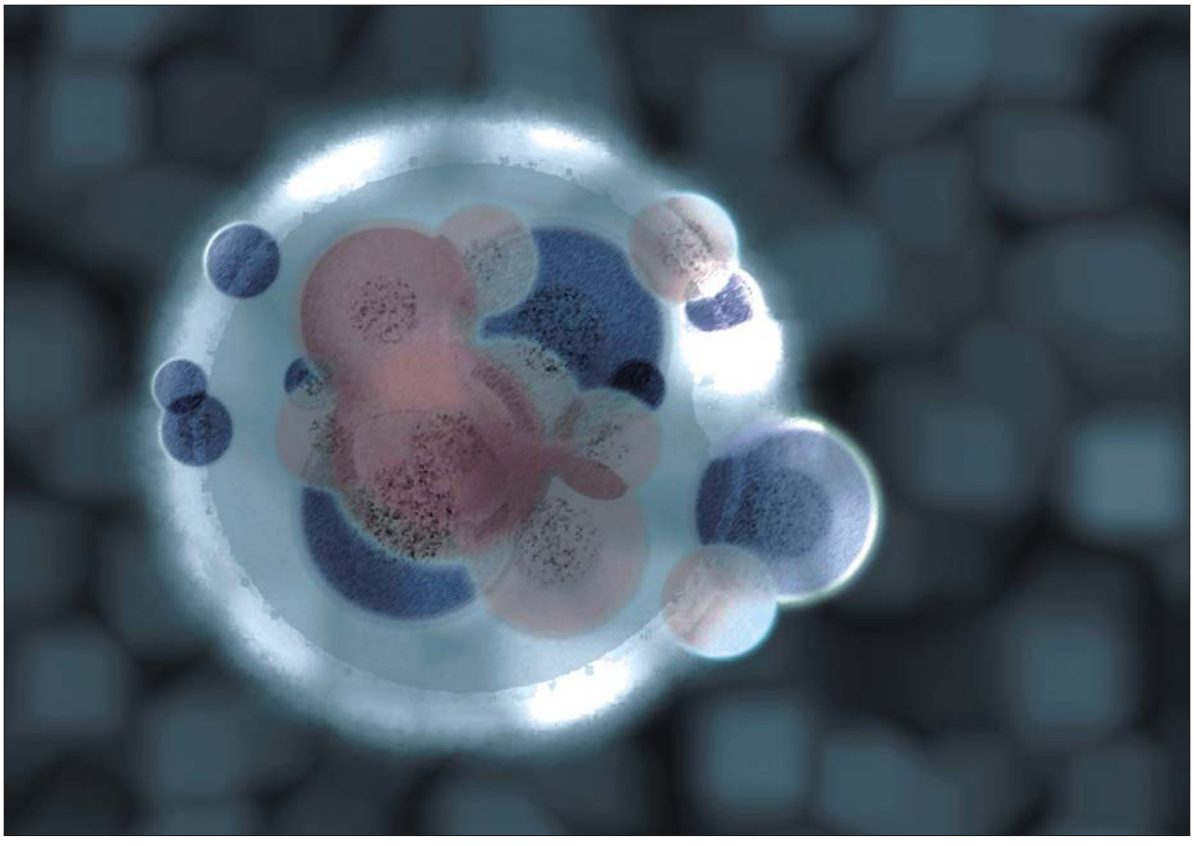

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Increment and Growth in Crimean Juniper (*Juniperus excelsa* Bieb.) Stands in Isparta-Sütçüler Region of Turkey

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Abstract: In this study, increment and growth of Crimean juniper in undisturbed, normal canopy, pure, even-aged and naturally grown stands depending on age and site quality were investigated in Isparta-Sütçüler region of Turkey. Increment and growth of Crimean juniper were obtained from 8 sample plots. They were taken in Central-Sütçüler (5), Tota (1) and Sipahiler (2) Forest subdistrict. Stand measurements from these sample plots were determined as per hectare volumes and volume elements of stands. As a result, increment and growth values of Crimean juniper found low. In general, the stand structure of a large portion of the Crimean juniper have been deteriorated, by negative factors such as prolonged mismanagement in the history, overuse, grazing intensity, silvicultural problems. Due to these problems, majority of single tree crown and stem form were bad.

Key words: Crimean juniper, increment, growth, age, site quality

INTRODUCTION

Juniper is the forest tree that spread out largely in Turkey. It takes an important place as an area and stem volume especially in Mediterrenean Region[1]. The juniper species have 78.58 ha well high forest, 1, 155.57 ha disturbed high forest and totally 1,234.16 ha[2].

Juniper can grow on poor areas that other forest tree can not grow. It's so hard to bring the other kinds of trees to juniper areas. In juniper forests reproduction and production studies can not be continued because of the unknown silviculture techniques. Common juniper species Crimean juniper which is our subject starts to heart rot on stem after 80 years old[1].

There is not enough information about increment and growth on juniper species for Turkey. The volume in the juniperus forests area is 18, 178.17 m^3 [3]. Average volume per hectare is 19.60 m^3 ha^{-1}. For the middle site quality in 100 years old stand, in the Crimean juniper yield table shown as 163.90 m^3 ha^{-1}. So, our juniper stands must be taken with an importance and their establishments must be made good[4].

The wood can be utilized in many field, therefore, this required to be improved of structure and acquired to productive country forests of degraded and old juniper stands. Turkey has Crimean juniper stands of juniper species. Other juniper species are in small quanting and forming individual complexity[1].

Junipers are slow growing and poorly suited to measurement methods used for temperate tree species[1,13].

In this study, increment and growth of Crimean juniper in undisturbed, normal canopy, pure, even-aged and naturally grown stands were investigated in Isparta-Sütçüler region of Turkey depending on age and site quality. Volume and volume elements of the stands with the sample plots were determined. The other main forest, *Pinus nigra* Arnold (Crimean pine) and *Cedrus libani* A. Rich. (Lebanon cedar) which can form mixed forest with Crimean juniper were aimed to compare depending on increment and growth properties.

MATERIALS AND METHODS

The botanic and silvicultural properties of Crimean juniper: Crimean juniper is 15-20 m long, top part is conic when young but round when it is old. Diameter at breast height (diameter) is nearly 80 cm for an old and single tree. The bark is grey brown and regular when young, has fiber bands when it is old. Juniper taxon has 5 species naturally in Turkey. These are *Juniperus oxycedrus* L., *J. phoenicea* L., *J. sabina* L., *J. foetidissima* Willd and *J. excelsa* Bieb.

Crimean juniper available from the low sea climate effects to high step. It's the tree of moderate climate. It can survive in cold, hot and drought. It can grow on shallow and stony soils. This species require light like

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Pinus nigra Arnold. It is the most common tree after Lebanon cedar in the Taurus Mountains. With the destruction of Lebanon cedar, it becomes dominant[5]. It spreads largely in Macedonia, Aegean territory and Greece islands, small Asia, Caucasus, Iran and Lebanon[5,6].

Crimean juniper starts in altitude of 500 m and goes up to 2500 m. It is found inner parts of the mountains to step limits in all Anatolia and mix mostly with *Juniperus foetidissima*. In this region, it reaches close to Mediterranean climate region. It can be encountered. In this regions, especially near the steps, dry, stony, shallow soil and mountainous area.

The reproduction problem of juniper needs to be solved in short period and to start forest management plan application in juniper areas[1]. We have got large and degraded juniper areas. The study of bringing the other harmonious main forest trees to the juniper areas is not successful. The solution of turning these areas to normal establishments is again juniper species.

If juniperous regeneration is protected, young trees terminal shoot starts to grow in short time and gains a regular form[7].

Study area and climate properties

Study area properties: In forest management plan Sütçüler region dispersion properties of juniper stands are shown in Tables 1, 2 and 3. Structure of Crimean juniper stands are generally destroyed or well destroyed.

Climate properties: The average monthly climate values (from 1930 to 1970) of Eğirdir Meteorological station (950 m) are used to determine the climate properties of focus area. According to the enterpole values of sample plots (1450 m), the average precipitation is annually 923.60 mm and the 26% of this precipitation is in spring, 11% is in summer, 17% is in autumn and 46% is in winter. The average temperature in annual is 11°C. In juniper spreading area, the hottest month is July and August, in these months. The average temperature is 21.6°C. The absolute maximum temperature is 32°C in July, the absolute minimum temperature is -12.2°C in February.

"Precipitation effective index" Erinç's[8] formula was used to determine the precipitation, vegetation cover and climate of area. According to the results, climate is semi-humid and the vegetation cover is dry forest like park appearance.

In the present research, the stand types and site quality maps in forest management plans were used. After taking information from technical workers and looking at present maps in forest management plans, the stands which have

Table 1: The distribution of juniper forest area according to the mixture and productivity

Forest subdistricts	Productive		Unproductive		
	Pure	Mixed	Pure	Mixed	Total (ha)
Sipahiler	5029.0	930.0	1818	1482.0	9259.0
Tota	343.5	29.5	903	361.0	1637.0
Sütçüler	3588.5	530.5	6069	6448.5	16636.5
Total ha	8961.0	1490.0	8790	8291.5	27532.5

Table 2: The distribution of juniper forest according to the canopy

Forest subdistrict	Canopy (%)		
	0.00-0.10	0.11-0.40	0.41-0.70
Sipahiler	3300.0	3648.5	2310.5
Tota	1264.0	273.0	100.0
Sütçüler	12517.5	3568.0	551.0
Total ha (%)	17081.5(62)	7489.5(27.2)	2961.5(10.8)

suitable properties were determined in the selection of sample plots.

The undisturbed, normal canopy, pure, even-aged and naturally grown juniper stands were selected carefully. After the first step 8 sample plots were chosen in order to determine increment and growth in Crimean juniper. Sample plots were taken in Central-Sütçüler (5), Tota (1) and Sipahiler (2) Forest subdistrict.

In order to obtain stand and site characteristics of sample plots compasses, altimeter, height meter (Blume Leiss), pressler increment borer, caliper and steal tape were used.

Diameter, height, age and diameter increment were determined in sample plots and all measurements were carried out in 2002 summer.

Sample plots characteristics are listed below (Table 4):

1. Above sea level, 1290-1560 m,
2. Aspect, sunny (2) and shadow (6),
3. As an incline group, little (2) and very incline (6) hillsides,
4. Relief (area surface shape), middle (6), lower (1) and upper hillsides (1),
5. Size of sample plots, 30x30 m (3), 30x20 m (5) square and rectangular.

The middle age of sample plots was found by using arithmetic average of minimum 4-6 middle tree stump age with the help of pressler increment borer. Middle ages of sample plots were in between 101 and 173 (Table 4).

To obtain the number of trees per hectare, the number of thick trees (more than 8 cm diameter) was converted into hectare. With this method, total number of trees per hectare were in between 367 and 767 (Table 5).

Total basal area of trees determined from sample plots. Stand basal area was converted into hectare. Basal

Table 3: Volume and volume increment of Crimean juniper according to the stand types

	Tota and Sütçüler forest subdistrict				Sipahiler forest subdistrict			
Stand type*	V m^3	Iv m^3ha^{-1} year	N ad ha^{-1}	G m^2ha^{-1}	V m^3	Iv m^3ha^{-1} year	N ad ha^{-1}	G m^2ha^{-1}
$Arcd_1$	88.650	1.594	253	6.011	77.073	0.878	193	7.770
$Arcd_2$	97.884	1.318	130	9.369	98.948	1.134	352	10.603
BAr	8.0	0.100	-	-	32.312	0.130	-	-

*Ar: Juniper, Diameter; c=20-35 cm and d=36–52 cm, Canopy (%); 0.11-0.40= 1 and 0.41-0.70=2 and B= unproductive juniper area

Table 4: Site description and characteristics of the sample plots

Sample plot No	Forest administration	Forest subdistrict and region	Altitude (m)	Aspect	Slope (°)	Relief	Area of the sample plots (m)	Age (year)
1	Sütçüler	Sipahiler Kızılot	1460	South	17	Middle Hillside	30x20	137
2	Sütçüler	Sipahiler Kızılot	1400	Northeastern	19	Middle Hillside	20x30	173
3	Sütçüler	Tota Ardıçalan	1560	East	5	Middle Hillside	30x20	102
4	Sütçüler	Sütçüler Ardıçalan	1540	East	5	Middle Hillside	30x20	161
5	Sütçüler	Sütçüler Ardıçalan	1530	South	17	Valley Ground	30x30	129
6	Sütçüler	Sütçüler Ardıçalan	1420	East	17	Middle Hillside	20x30	101
7	Sütçüler	Sütçüler Zengialan	1290	Northwestern	20	Middle Hillside	30x30	123
8	Sütçüler	Sütçüler Zengialan	1390	Northwestern	16	Ridge	30x30	151

Table 5: Volume and volume elements of the sample plots

					Per hectare						
Sample plot No	Average diameter (cm)	Average height (m)	Top height (m)	Average volume (m^3)	Number of trees (ad ha^{-1})	Basal area (m^2ha^{-1})	Volume (m^3ha^{-1})	Current annual volume (m^3ha^{-1})	Site index (m)	Site quality	Age (year)
1	30.3	9.7	11.3	0.318	767	55.4	246.3	1.981	9.64	II	137
2	32.4	10.2	12.8	0.381	367	30.3	163.0	1.521	9.76	II	173
3	40.1	14.4	14.8	0.758	467	58.9	355.2	3.607	14.80	I	102
4	36.2	11.2	11.4	0.521	383	39.5	200.2	1.456	8.96	III	161
5	31.4	10.3	10.7	0.356	444	34.3	165.5	2.108	9.30	III	129
6	26.3	7.4	8.0	0.196	483	26.2	99.8	1.304	7.95	III	101
7	34.9	11.7	12.0	0.491	511	48.8	245.3	2.618	10.64	II	123
8	34.2	9.7	11.5	0.322	500	36.5	200.3	1.663	9.00	III	151

Sample plot 1 (T=137, SQ=II) Sample plot 3 (T=102, SQ=I) Sample plot 5 (T=129, SQ=III) Sample plot 2 (T=173, SQ=II)
Sample plot 4 (T=161, SQ=III) Sample plot 6 (T=101, SQ=III)

areas of sample plots were in between 26.20 and 58.90 m^2 (Table 5).

By measuring the height and diameter of 20-25 tree, stand height curve was made in every sample plot. Middle diameter was taken as basal area of middle tree diameter for a sample plot. Middle height was found from stand height curve (Table 5).

In this research, top height was determined from stand height curve with the help of the average diameter of 100 thickest diameter trees. By using top height and middle age from the Crimean juniper Site Quality Table[1] top heights which are at standard ages were between 7.95 and 14.80 m (Table 5). Sample plots distributed one good site quality, three middle site quality and four poor site quality, respectively.

To find single tree stem volume then all the stand volume, volumes of all the trees that are in sample plot were added with the Aykin's[9] stem volume table and as a result volume of the sample plot was found. This value was converted into hectare and volumes in per hectare were determined. The volumes of sample plots per hectare were in between 99.80-355.20 m^3 (Table 5).

The last 10 year annual ring thicknesses at breast height were measured from the trees that are at different diameter classes with the pressler increment borer. The increment of volumes was calculated with the Meyer's Interpolation method. Volume increments per hectare of sample plots were in between 1.304 and 3.607 m^3 (Table 5).

Statistical analyses: The measurements of sample plots were appreciated with the MS Excel software program on computer processing data register. Simple and multiple regression analyses were made with the help of

Fig. 1: Nearby parent rock to the surface, dry natural stem and branches is seen (sample plot 8)

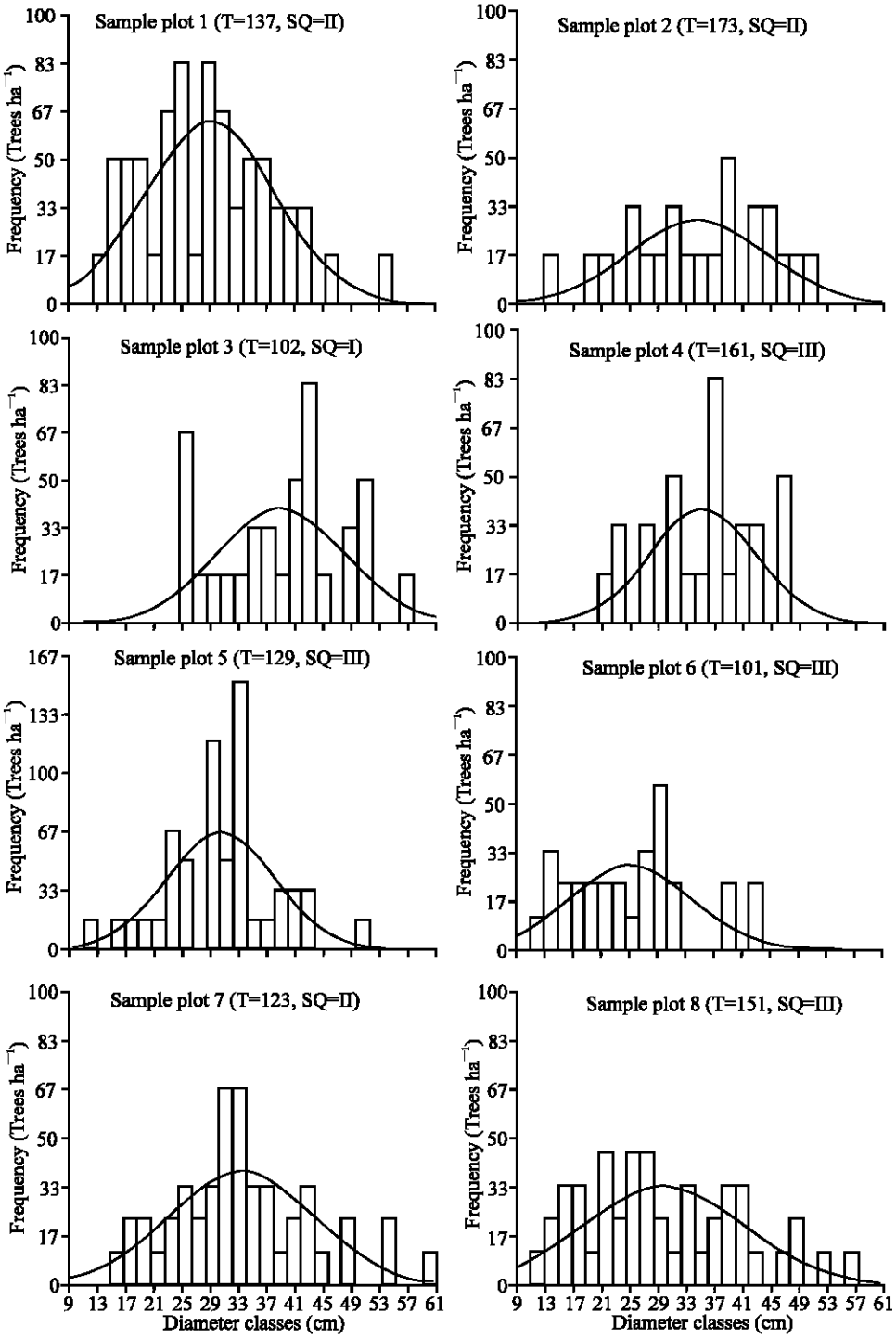

Fig. 2: The alteration number of trees in diameter classes in the sample plots (T=average age of stand, SQ=Site Quality)

these data registers. Separately, correlation coefficient, coefficient of determination and values of standard error (Se) belong to regression equations were calculated.

Diameter at breast height (d-cm) and heights (h-m) were assigned in to x, y coordinates one by one for every sample plots and then stand height curves were obtained

by regression equation 1.

$$h= a_0+a_1*d+a_2*d^2 \quad (1)$$

Diameter and diameter increments (id -mm) were pointed to different x,y coordinates for young and old sample plots, then diameter–diameter increment regression lines were obtained by regression equation 2. Sample plots were grouped as young (3, 5, 6 and 7) and old (1, 2, 4 and 8) sample plots.

$$id= a_0+a_1*d \quad (2)$$

The estimated values were shown on the real values as graphically. Frequency of every diameter class was found as 2 cm steps for every sample plots. (9 cm is middle step and maximum diameter 62 cm). Frequencies of sample plots were modified into hectare. Then, the distribution the number of tree to diameter classes was shown on graphic in sample plots.

RESULTS

Increment and growth of volume and volume elements: The stand structure of a large portion of the Crimean juniper have been deteriorated, majority of single tree crown and stem form bad, by negative factors such as prolonged mismanagement in the history, overuse grazing intensity, silvicultural problems (Fig. 1).

The distribution of sample plots of the number of trees per hectare to diameter classes is examined. Distribution of tree number to diameter classes is lightly skewed to right when young, but symmetrical when old (Fig. 2). This structure shows that Crimean juniper needs more light when old.

The relationship between diameter and diameter increment: The relationship between diameter and diameter increment have shown big distribution in Crimean juniper young stands because of the alteraty of crown greatness of the trees and social classes. The reason that learning from the relationship between diameter and diameter increment in the old stand, is decreasing of the difference diameter increment between the tree social classes and separating the defeated trees.

In an old stand, the relationship between diameter and diameter increment demonstrated a horizontal tendency. Due to the fact that, the competition becomes minimum levels, generally victorious stems were surviving in the area and narrow annual ring is forming in thick diameter stems. Diameter- diameter increment values of sample plots were balanced (Fig. 3).

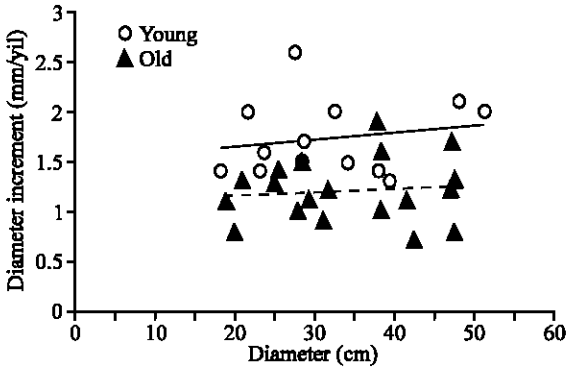

Fig. 3: Variation of diameter and diameter increment depending on the young (3,5,6 and 7) and old (1,2,4 and 8) sample plots groups

The increment and growth relationships crimean juniper with lebanon cedar and crimean pine: Lebanon cedar, Crimean pine and Fir must be a mixed in places with Crimean juniper where Crimean juniper spread out naturally. Except fir, depending on the age and site quality, Crimean pine[10] Lebanon cedar[11] and Crimean juniper[1] were studied about increment and growth. Yield tables of these species were prepared.

In order to obtain a more correct result for the first site quality classes of every tree species, values of yield table are used[12]. In the present research, comparison of top height, basal area, total volume and current annual volume increment between Crimean juniper and Lebanon cedar and Crimean pine was made by using the values of first site quality classes (Fig. 4). Crimean juniper grows slowly than Crimean pine and Lebanon cedar. Basal area of Crimean juniper is quite close to Lebanon cedar but it's total volume per hectare is low, because of the slow height growth. The reason of having low volume fertility force in Crimean juniper is bad environment conditions and genetic properties (Fig. 4).

DISCUSSION

The distribution of the number of trees to diameter classes is lightly skewed to right when it is young, but symmetrical when it is old (Fig. 2). This structure shows that Crimean juniper is semi intolerant tree when it is young.

In young stands distribution of points relating to diameter- diameter increment shows big distribution and a perpendicular incline. However, in old ones, the variation between the distributions of points is declining and dispersion shows a horizontal incline. The reason of

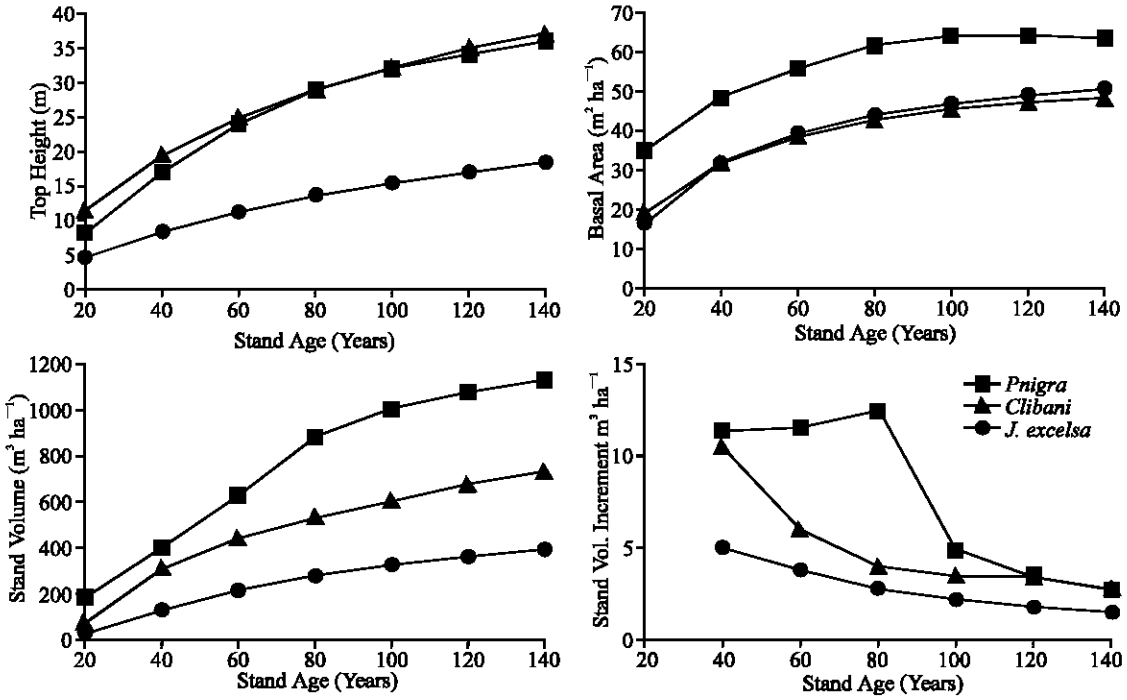

Fig. 4: Alteration of top height, basal area, total volume and current annual volume increment depending on the stand age in Crimean pine, Lebanon cedar and Crimean juniper

this is the diameter increment difference between the tree social classes and it becomes small with age and separating of defeated trees (Fig. 3).

The values of volume and volume elements of Crimean juniper are lower than Crimean pine and Lebanon cedar because of the genetic properties (Fig. 4). Structure of Crimean juniper is generally destroyed or very destroyed. When comparison is made between the age and site quality of sample plots and values of volume current annual volume increment of Crimean juniper yield table, volume gives similar results with the yield table but volume increment is too low (Fig. 4).

The silvicultural treatments that are applied today, are cutting to clean and removing the very old ones. In addition to that, production and regeneration studies are stopped for a long time. For these reasons, potential juniper stands must be transformed to other establishments that can be functional about production and out of production with the scientific studies.

The production force of volume and volume elements of old Crimean Juniper stands are low. For this reason old stands must be regenerated and young ones must be improved. The reason for that, if the stand density is low from a critic point (according to the age and species, 60-80%) production of stem wood is declining.

Establishments of stands with the silvicultural practices must be improved. Otherwise, establishments of Crimean juniper stands will be damaged in future. The success of bringing the other main tree species which one suitable for the Crimean juniper areas is low. The solution of turning these areas to normal establishments is again using juniper species.

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